GUIDELINES FOR EVALUATION OF CF INDOOR FIRING RANGES

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ABSTRACT

A guideline has been prepared to assist the Preventive Medicine Technician (PMT) at the base level to monitor inorganic lead concentrations in indoor firing ranges during weapons firing. From the mean lead levels obtained, safe occupancy periods may be derived from the maximum allowable exposure table included in the report. The complete technical approach which includes air monitoring and ventilation measurement techniques is outlined in detail. This sampling strategy, if followed should be of assistance to the PMT in evaluating an indoor firing range. Also included are housekeeping recommendations regarding safe practices.

OBJECTIVE

During the past few years, DCIEM has been tasked by the Directorate of Preventive Medicine (DPM) to evaluate indoor firing ranges within the Canadian Forces. These evaluations consisted of measuring the level of aerosolyzed lead in the range during use, and assessing existing ventilation conditions. One objective of these investigations was to develop methods whereby the Preventive Medicine Technician (PMT) at the base level, could perform these evaluations using guidelines established by the U.S. Army Health Services Command and techniques adopted by this Institute.

INTRODUCTION

Regular Force personnel, as well as Militia and Cadets utilize indoor firing ranges year round for training and firing of small bore weapons. When a weapon is fired, the burning of the primer results in the vaporization and fragmentation of the projectile which releases inorganic aerosolyzed lead. Carbon monoxide and oxides of nitrogen are also liberated into the atmosphere. However, the main occupational health concern is for the inorganic lead concentrations.

Prolonged absorption of lead or its organic compounds, from inhalation of vapour, fume or dust, as well as oral ingestion; can cause severe gastro-intestinal disturbances and anemia with symptoms of anorexia, constipation, abdominal discomfort, weakness, fatigue, malaise, headache and pallor (2).

Personnel using these ranges could be exposed to inorganic lead levels above the NIOSH/OSHA Permissible Exposure Limit/Time Weighted Average (PEL/TWA). This standard currently is 0.05 mg/m^3 (based on an 8-hour work day, 40 hr work week) (2). Since the exposures to inorganic lead in indoor firing ranges are usually intermittent and do not fit the time criteria of an 8-hr day 40-hr week exposure standard, the US Army Health Service Command has developed a table of maximum allowable exposure times based on airborne aerosolyzed lead in any given range. (5) (Table I).

METHODS

a. Air Sampling

In order to assess a range lead samples should be collected by the use of personal monitoring air sampling pumps connected to filter cassette assemblies. The filter cassette assembly will contain a Cellulose Ester (CE) filter, 37 mm diameter and 0.8 micrometers (μm) pore size, with a 37 mm filter pad. Closed face sampling should be employed and the 3-piece filter cassette assembly sealed with a cellulose band. Figures 1 and 2 illustrate this required assembly. The sample flow rate should be 1 to 4 litres per minute (Lpm) for a

minimum volume of 250 litres (3,5). Previous surveys conducted by this Institute employed a sampling flowrate of 2 Lpm.

b. Sample Locations

Breathing zone samples must be taken on the shooters at each firing point if there are less than six, and on shooters at every other firing point if greater than six, plus the Range Safety Officer. An equal number of static samples must be also taken ten (10) feet behind the firing line at each respective firing point and one in an area immediately adjacent to the range (i.e., store room, range office, hallway, see Figure 3). A minimum of two (2) background samples should be taken for one hour prior to commencement of firing, one located at the butt area and the other at the firing line. For purposes of analysis, at least one blank (caps off, no air flowing through) sample located at the firing line during firing must also be prepared (5). Following analysis of the lead of each filter, the mean airborne lead concentration of all samples is then used to derive a Maximum Allowable Exposure (MAE) time from the enclosed table (Table 1).

c. Calibration

All sampling pumps must be calibrated on site before and after use, using a mass flow calibrator or bubble burret (Figure 4). Each pump must be calibrated with the complete filter cassette assembly in line.

VENTILATION

Supply and exhaust air velocities can be measured using a calibrated velocity meter. For round ducts larger than 6 inch diameter, at least 10 pitot tube traverse readings should be taken. For square or rectangular ducts divide the cross-section into a number of equal rectangular areas and take a minimum of 15 readings (1).

To determine supply and exhaust air volume use the formula Q=VA (1):

Q = quantity of air flowing, cfm (cubic feet per minute)
A = cross-sectional area of duct, sq ft, measured
V = Average linear velocity, fpm (feet per minute)

Optimum ventilation systems should include supply air behind the firing line and exhausted air at the butt area. The air velocity at the firing line is measured using the air velocity meter.

Exhaust air should exceed supply air by 10 percent to provide a slightly negative pressure within the range. Optimum and minimum air supply velocity at the firing line is 75 fpm and 35 fpm respectively (5).

RANGE EVALUATION

Once an indoor firing range has been monitored for inorganic lead the samples must be sealed, correctly labelled and then sent to a competent analytical laboratory for analysis. The results obtained will usually be sent back in the form of micrograms per filter unit. To convert these values to mg/m^3 of airborne lead, it will be necessary to use the following formula (3):

$$mg/m^3 = \frac{\text{micrograms/filter}}{\text{air volume sampled (litres)}}$$

Example: The Range Safety Officer is monitored for 2 hrs with a pump having a flowrate of 2 Lpm (total air volume sampled 240 litres). The analytical laboratory result for this particular filter assembly read 294 micrograms/filter. To convert the 294 micrograms/filter to a sampling point concentration in mg/m^3, the following steps are taken:

$$mg/m^3 = \frac{294}{240}$$

$$mg/m^3 = 1.2$$

Therefore the Range Safety Officer would have a lead exposure above the OSHA recommended PEL of .05 mg/m^3. Furthermore, by using the TWA formula (7):

$$\frac{C_aT_a + C_bT_b + C_NT_N}{8\ HR}$$

Where: T_a is the time of the first exposure period (hrs) C_a is the concentration of contaminant in period a (mg/m^3) T_b is the next sequential time in the 8-hr time period (hrs) C_b is the concentration during period b (mg/m^3)
T_N is the final time period
C_N is the concentration during period N

We can see that

$$\frac{1.2 \times 2 + 0x6^*}{8} = 0.3\ mg/m^3$$

Therefore the 8 hr TWA of .05 is also exceeded.
*0x6 refers to no exposure for the remainder of the 8-hr time period as the subject is out of the range.

The Maximum Allowable Exposure Table (Table I) may then be used by the FMT to evaluate the usage of an indoor firing range. Once the lead level results are obtained, appropriate recommendations can be

made as to the amount of time an individual may stay in the range without being over-exposed to inorganic lead. An individual who uses the range, only to qualify in small bore weaponry, would normally use it less than 30 days/year. If, while firing he is monitored, and the mean lead level concentration is between .15 - .20 mg/m^3 the PMT will refer to the Maximum Allowable Exposure Table (Table 1) and conclude the individual may fire 3 hrs/day up to maximum 9 hrs/wk without being over-exposed to inorganic lead.

It should be noted that the table is to be used as an interim measure only. Maximum effort must be made to correct any range deficiencies (i.e., ventilation, housekeeping, etc). Some guidelines and recommended practices regarding housekeeping are included in Annex A.

CONCLUSION

This report has been prepared to help the Preventive Medicine Technician evalualuate indoor firing ranges within the CF. It is recommended that the report be distributed to all Base PMT to aid them in carrying out range evaluations at their base should the need arise. In conducting these evalutions it is important that the following criteria are adhered to:

1. Approved air sampling methodology is employed (Refs 3&5).

2. The sampling strategy outlined in this report is closely adhered too.

3. Only an accredited laboratory be requested to carry out the filter analysis for lead.

4. The results obtained from any one survey apply to that particular range, selection of weapons and intensities of firing employed at the time of the survey. Any gross changes in range utilization or engineering modifications will necessitate a re-evaluation.

5. Approved ventilation assessment methodology are employed Ref 1).

RECOMMENDED HOUSEKEEPING PRACTICES FOR INDOOR FIRING RANGES

a. The ventilation system should be in operation during all cleanup procedures;

b. Only an approved NIOSH respirator for lead dust and fumes should be worn during cleanup;

c. Wet methods or vacuum, not dry sweeping, should be employed during cleaning;

d. Smoking and/or consumption of food/beverages should be prohibited to avoid the ingestion of lead into the body; and

e. Shooters should be advised to wash hands thoroughly after firing (6).

ACKNOWLEDGEMENTS

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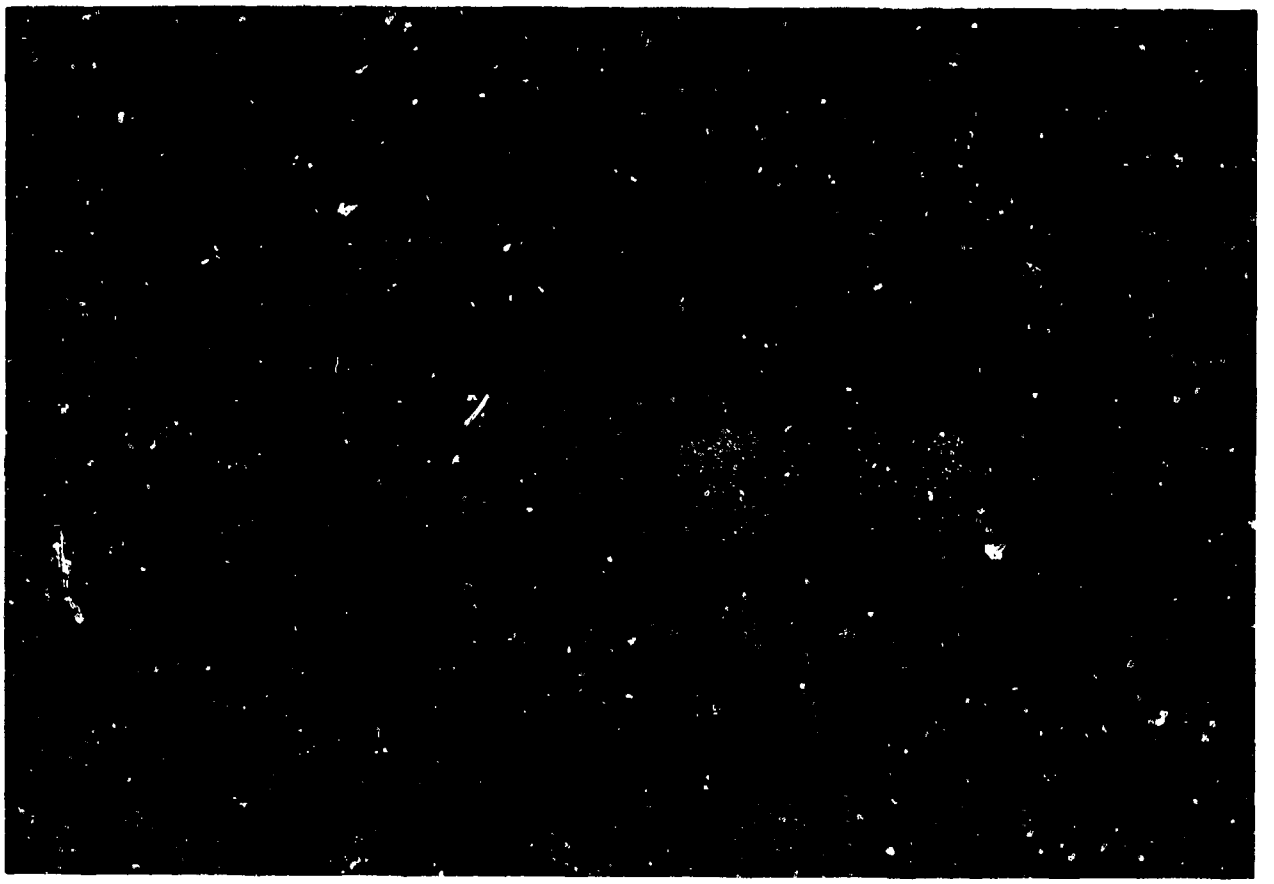
Table I

MAXIMUM ALLOWABLE EXPOSURE LIMITS FOR INTERMITTENT ATMOSPHERIC LEAD

AIRBORNE LEAD CONCENTRATION (mg/m^3)			MAXIMUM HOURS OF ALLOWABLE EXPOSURE			
			FIRING 30 OR MORE DAYS/YEAR		FIRING LESS THAN 30 DAYS/YEAR	
>		≤	Hrs/Week	Hrs/Day	Hrs/Week	Hrs/Day
0	-	0.03	40	8	40	8
0.03	-	0.05	24	8	32	8
0.05	-	0.10	12	6	18	6
0.10	-	0.15	8	4	12	4
0.15	-	0.20	6	3	9	3
0.20	-	0,25	4½	2½	7½	2½
0.25	-	0.30	4	2	6	2
0.3	-	0.4	3	1½	4½	1½
0.4	-	0.5	2½	1	3	1
0.5	-	0.7	1½	½	1½	½
0.7	-	1.0	1	½	1	½
1.0	-	2.0	½	½	½	½
2.0	-	4.0	½	½	½	½
4.0			0	0	0	0

Reprinted from "Control of Potential Lead Intoxication at Indoor Firing Ranges" 25 February 1981 with the permission of US Army Health Services Command, Fort Sam Houston, Texas, 78234.

Three (3) Piece Filter Cassette Assembly
for Inorganic Lead



NOTE: FILTER CASSETTE ASSEMBLED RIGHT TO LEFT

FIGURE 1

Closed Face Sampling Using Three-Piece
Filter Cassette Assembly and Bendix Corporation (Model BDX 44) Pump

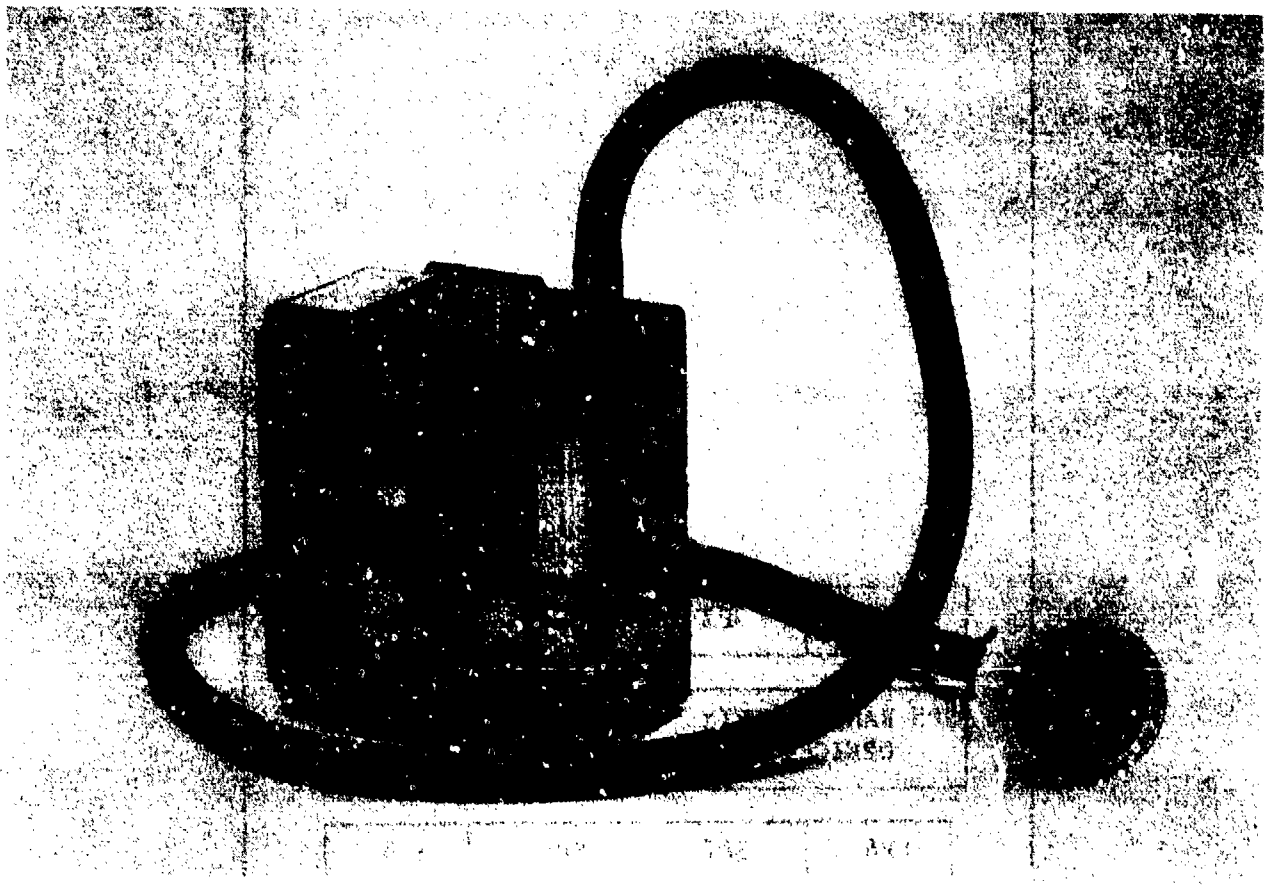
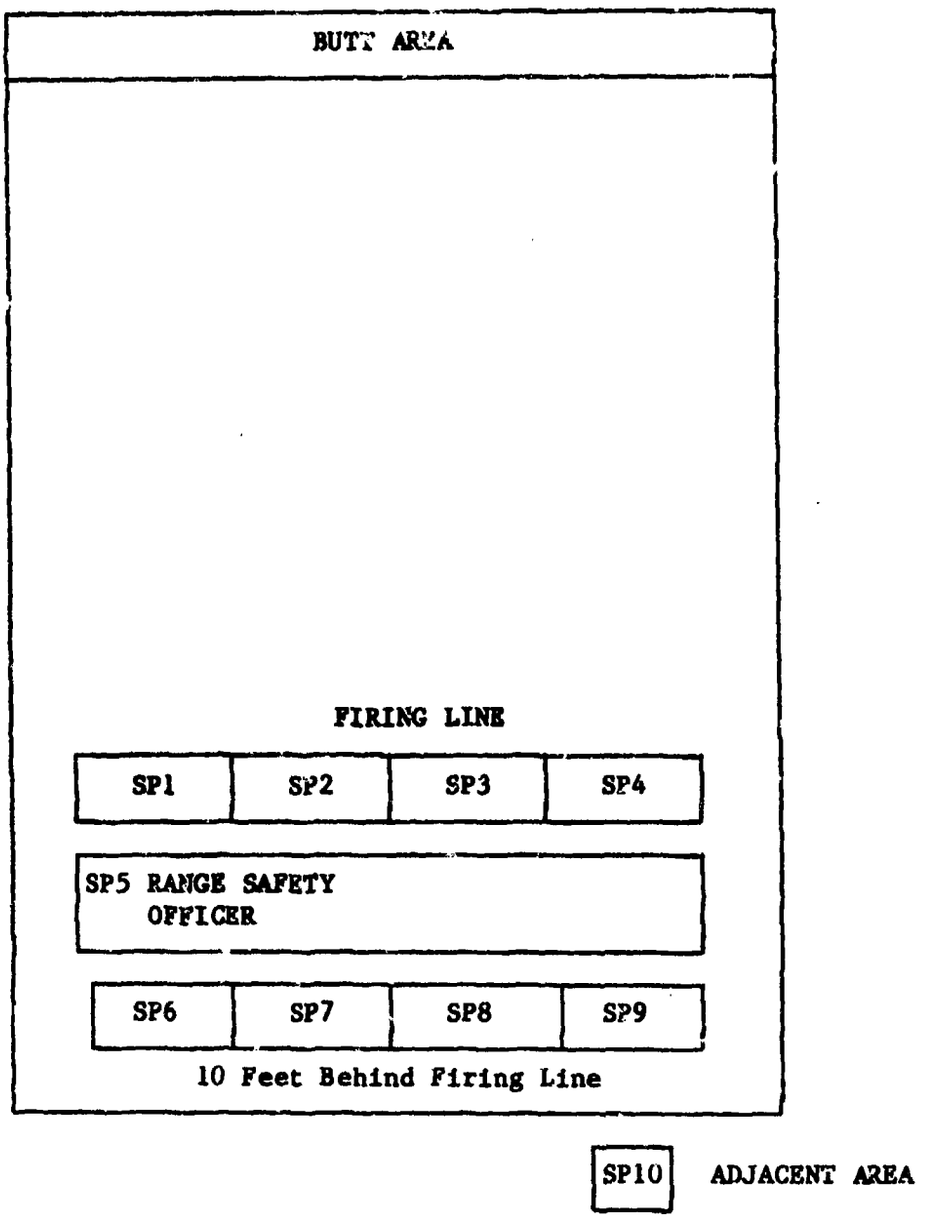


FIGURE 2



Recommended Sampling Point (SP) Locations
for an Indoor Firing Range Evaluation

FIGURE 3

Calibration of Bendix Corporation (Model BDX 44) Pump
Using Bubble Burret

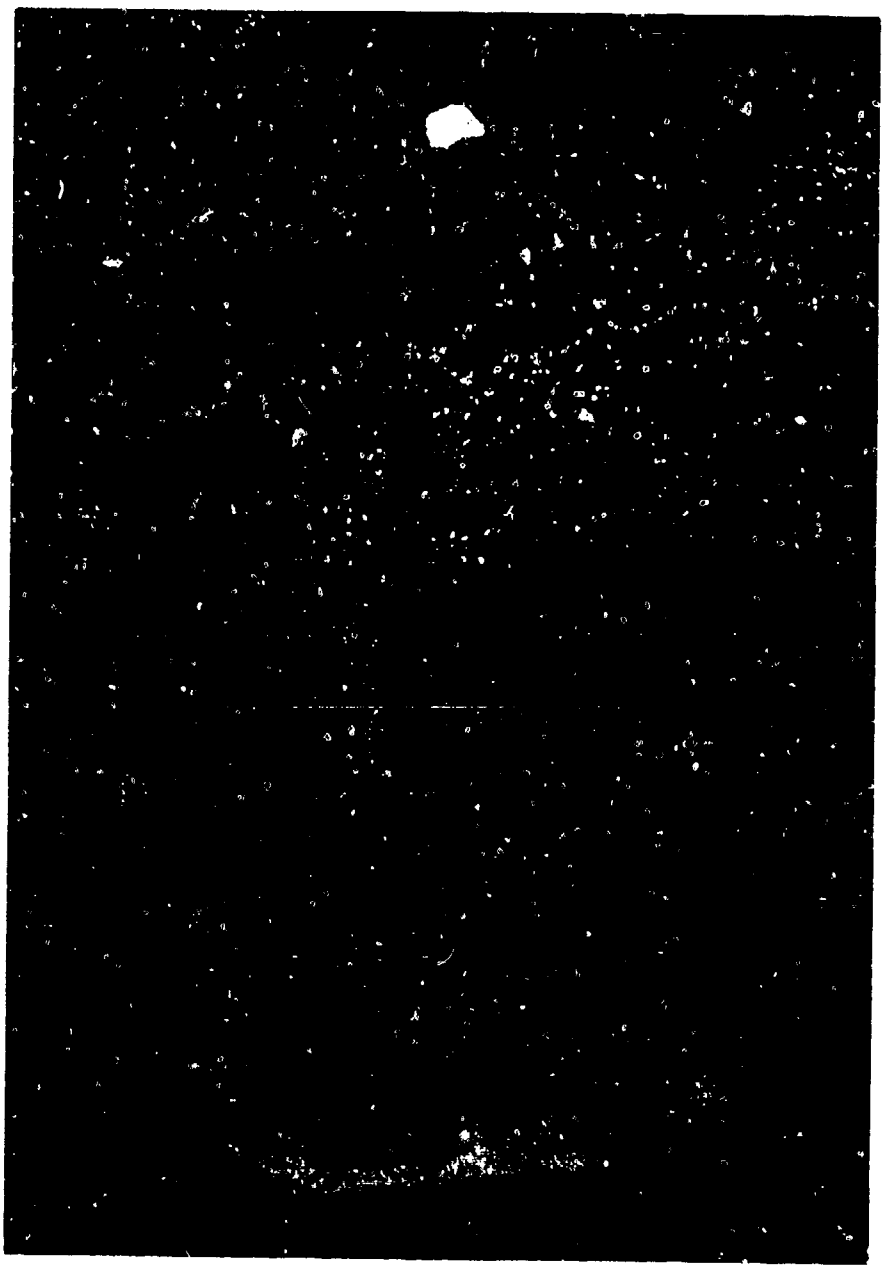


FIGURE 4